U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Hydrogen Program
Fuel Cell Technology

Nancy Garland for Patrick Davis

Office of Hydrogen, Fuel Cells, & Infrastructure Technologies

May 24, 2004

Fuel Cell Team Members

Nancy Garland – National Lab R&D

Kathi Epping – Stationary Fuel Cells

Donna Ho - Components

John Garbak – APUs, Air Management

Valri Lightner – Fuel Processing, Membranes

Amy Manheim – Inter-Agency, Membranes

Patrick Davis – Team Leader

Overview

- Goal & Objectives
- Budget
- Targets / Status
- Barriers
- Approach
- Technical Accomplishments
- Interactions & Collaborations
- Recent Awards
- Fuel Processing Go/No-Go Decision
- Future Directions

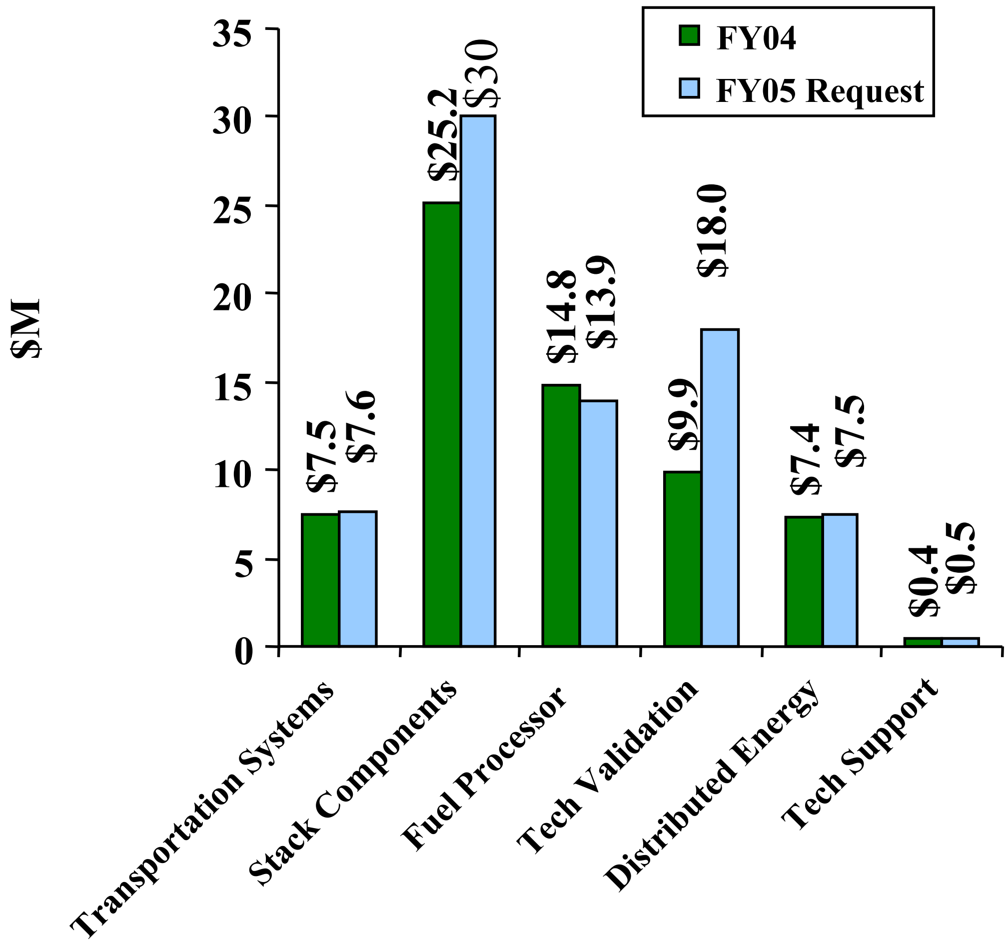
Fuel Cells Goal & Objectives

Develop and demonstrate fuel cell power system technologies for transportation, stationary, and portable applications.

1. Develop a 60% efficient, durable, direct hydrogen fuel cell power system for transportation at a cost of $45/kW by 2010 and $30/kW by 2015.
2. Develop a 45% efficient reformer-based fuel cell power system for transportation operating on clean hydrocarbon or alcohol-based fuel that meets emissions standards, a startup time of 30 s, and a projected manufactured cost of $45/kW by 2010 and $30/kW by 2015.
3. Develop a distributed generation PEM fuel cell system operating on natural gas or propane that achieves 40% electrical efficiency and 40,000 hours durability at $400-$750/kW by 2010.
4. Develop a fuel cell system for consumer electronics with an energy density of 1,000 Wh/L by 2010.
5. Develop a fuel cell system for auxiliary power units (3-30kW) with specific power of 150 W/kg and a power density of 170 W/L by 2010.

Fuel Cell R&D Budget

FY 2005 Budget Request = $77.5M
FY 2004 Appropriation = $65.2M

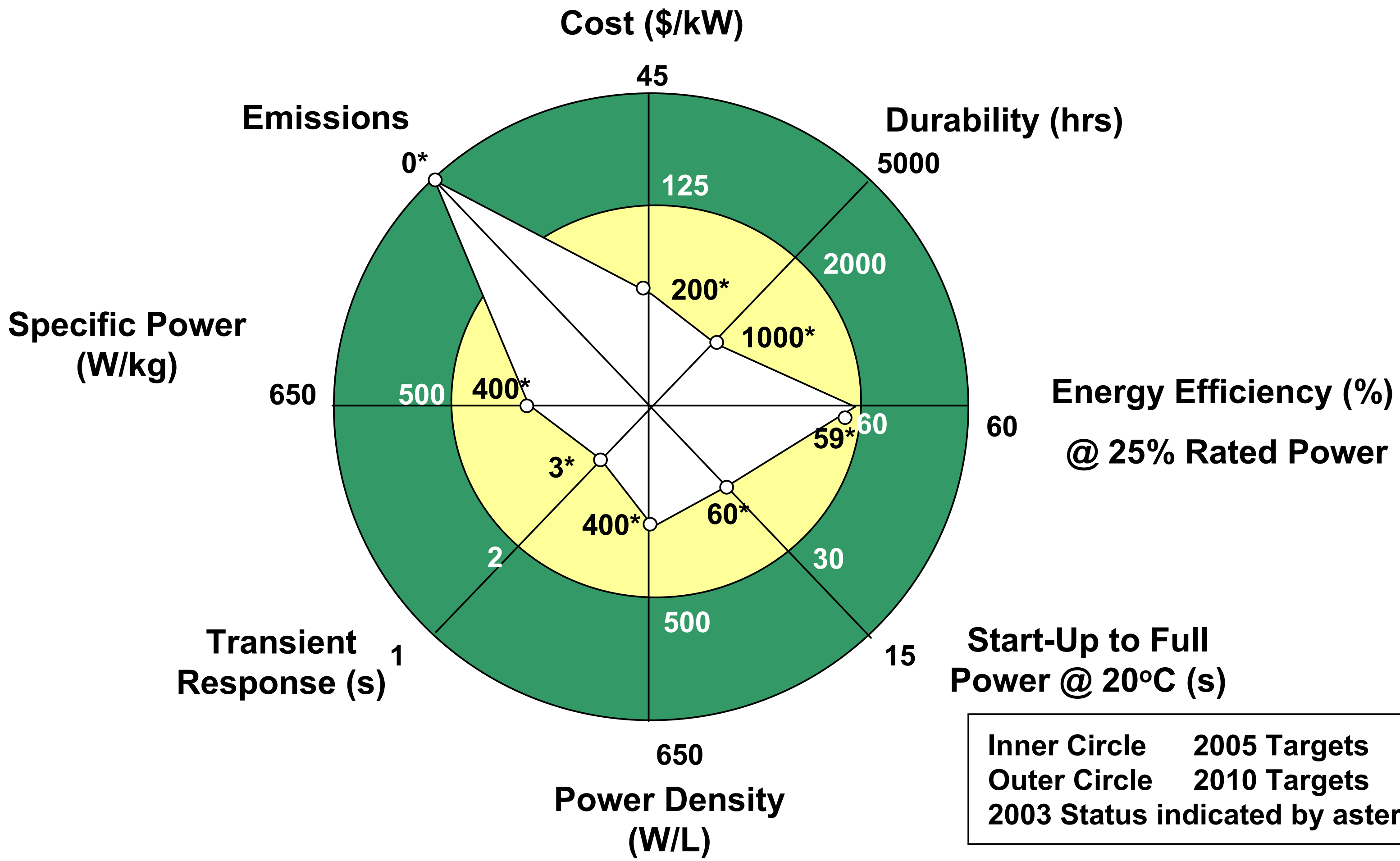


- **Emphasis:**
  - Advanced membrane R&D to improve durability and tolerance to feed gas impurities, increase performance at low relative humidity, and lower cost
  - Advanced catalyst R&D to improve performance, reduce platinum loading, and develop non-platinum catalysts
  - High efficiency Polymer Electrolyte Membranes for Stationary Fuel Cell Power Systems
  - Auxiliary Power Units for heavy vehicle applications
  - Demonstrations validating performance, durability, & reliability
  - Stationary reforming, auxiliary power reforming and fundamental fuel processing R&D

- **Budget Obligations:**

Industry R&D Contracts	$36.5M
Laboratory R&D	$20.0M
Technology Validation	$18.0M
Auxiliary power solicitation	$ 3.0M
Total	$77.5M

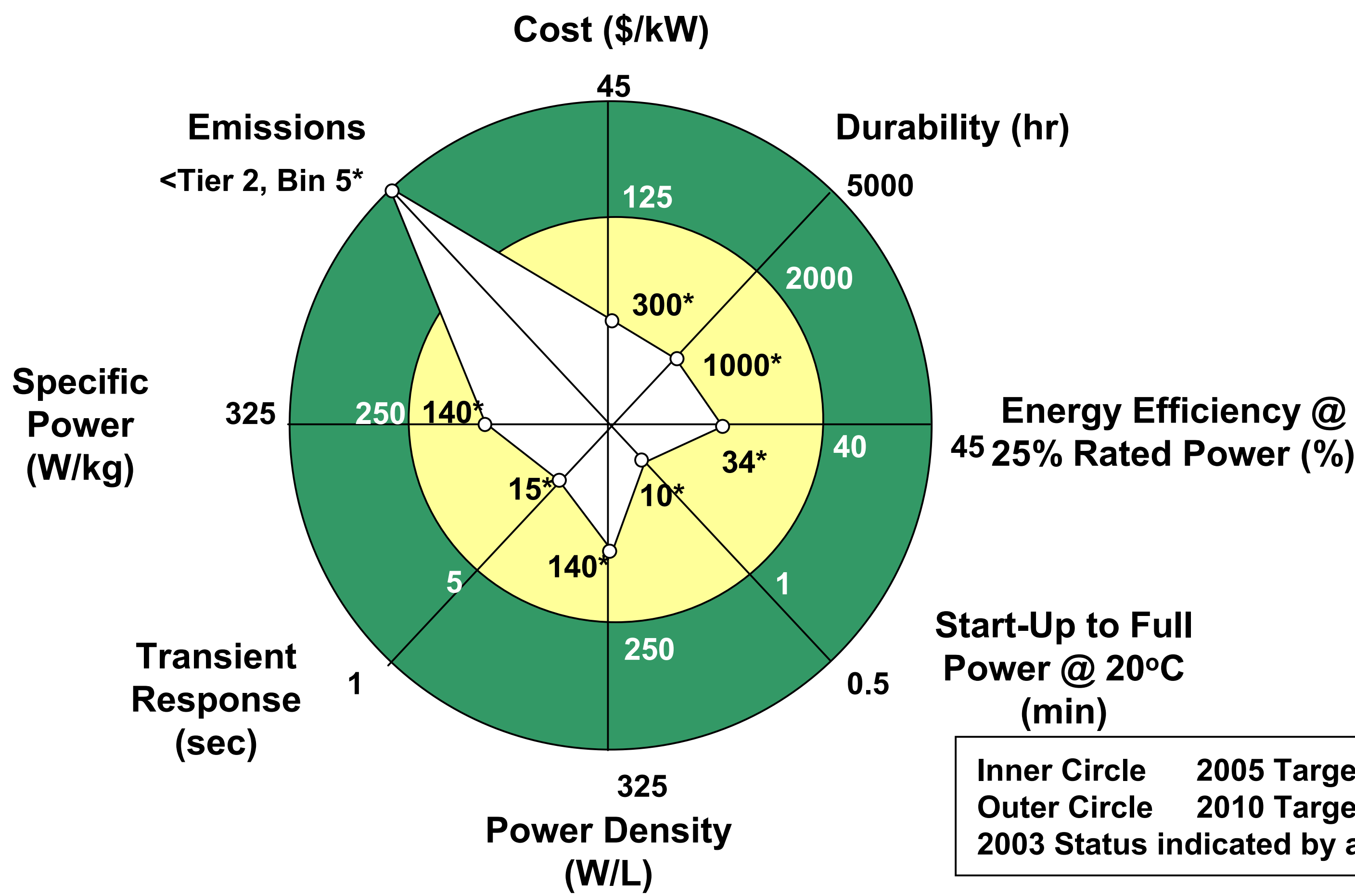
Direct-Hydrogen Fuel Cell System



Inner Circle 2005 Targets
Outer Circle 2010 Targets
2003 Status indicated by asterisk *

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Gasoline Reformer Fuel Cell System



Inner Circle	2005 Targets
Outer Circle	2010 Targets
2003 Status indicated by asterisk *	

Key Barriers

13 Individual Barriers detailed in the Multi-year Plan

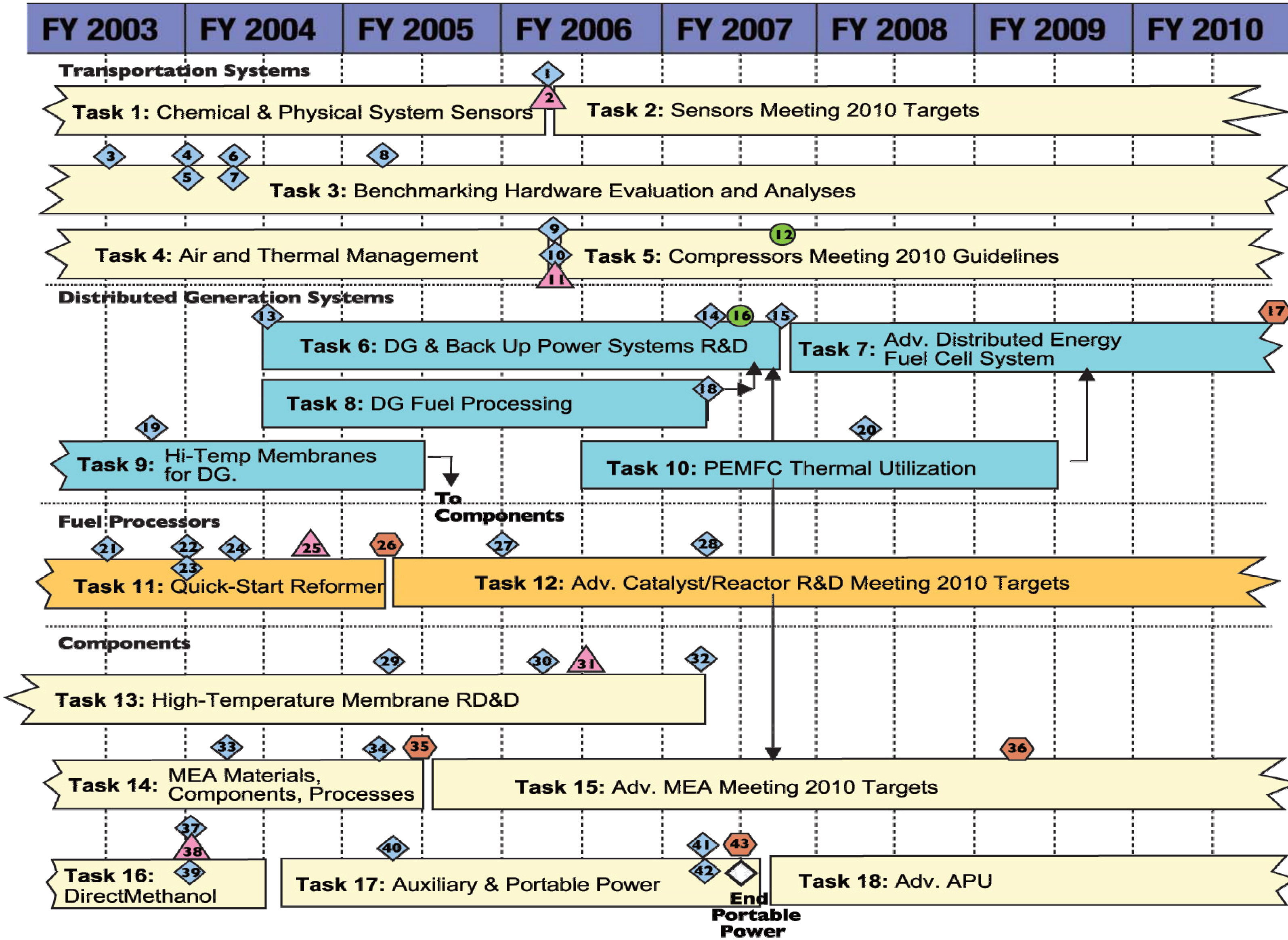
Recurring Themes

- Cost
- Durability
- Thermal and Water Management
  - Waste heat rejection
  - Waste heat utilization
  - Minimization of supporting systems
- Performance
  - Efficiency
  - Extreme temperature operation
  - Start-up and transient operation

Approach

- Work with industry partners to identify technical issues, establish goals, objectives and targets, and evaluate progress
- Focus on high risk R&D to remove barriers to commercialization
- Structure program to involve industry, academia and national labs, including teaming arrangements. Compete projects under cost-shared agreements.
- Structure appropriate programmatic timetables and project schedules with go/no-go decisions, milestones, and deliverables
- Measure progress regularly in a peer-reviewed process

Schedule and Milestones



Accomplishments

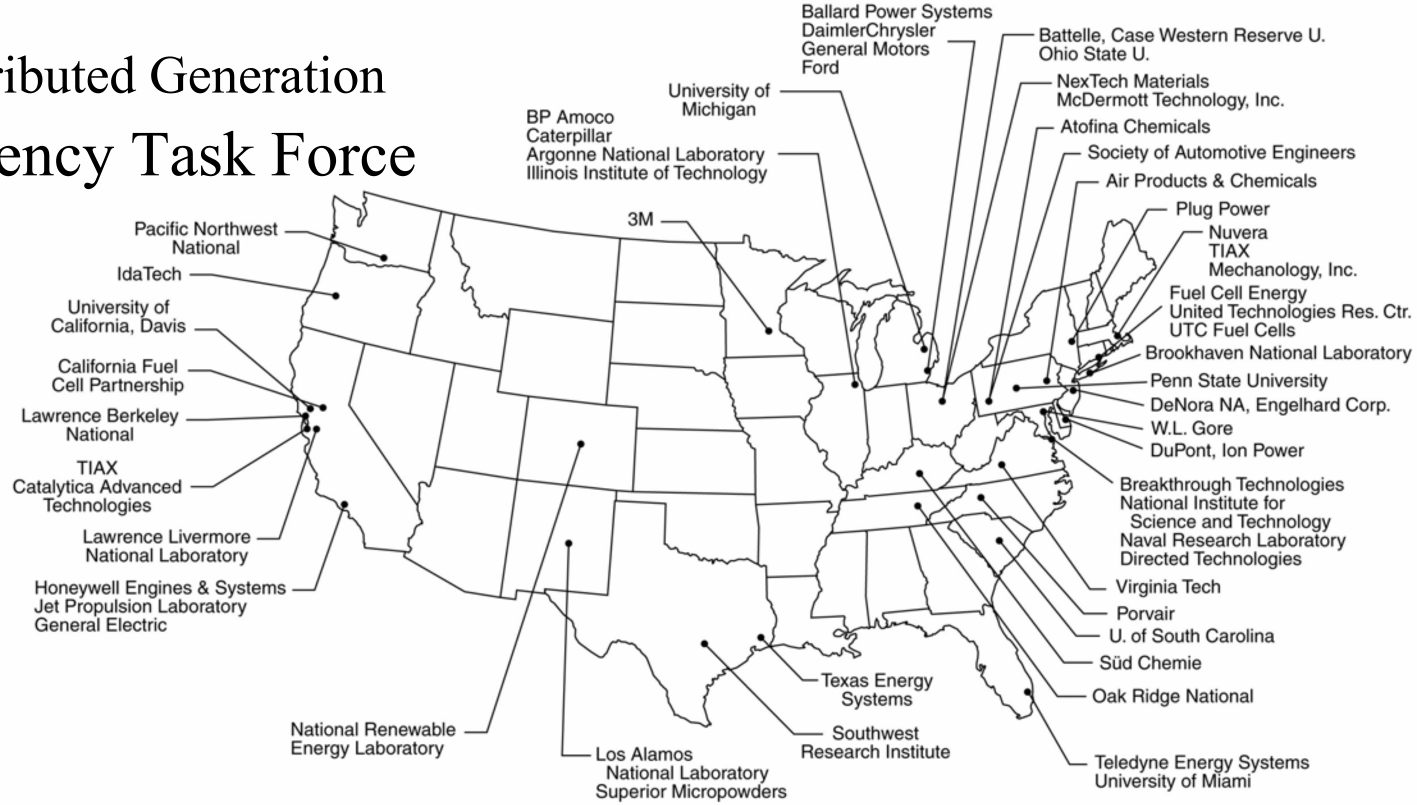
- LANL demonstrated 1000 hours fuel cell operation with ultra-low Pt loading (0.02 mg Pt/cm^2) in the anode (2005 total loading goal: 0.6g/kW).
- ORNL transitioned metallic bipolar plate nitriding process to stainless steel materials with good initial results.
- 3M project and initial Dow results show improved membrane durability.
- ANL-led industry/lab fuel processing project made excellent progress toward demonstrating 60 s start-up.
- DeNora demonstrated a membrane with proton conductivity >0.1 S/cm at <25% relative humidity at 120°C.
- UTC demonstrated Pt alloy catalysts with significant performance improvements.

Interactions & Collaborations

- Office of Fossil Energy
  - Coordination with SECA program
- Office of Science
  - Basic research efforts
- EERE
  - Distributed Generation
- Interagency Task Force

- Universities
- Industry
- Gov. Labs
- IPHE & IEA

- IAPG
- States
- FreedomCAR
- H_2 Fuel Initiative



Results of DOE Solicitations

- Last month Secretary of Energy Spencer Abraham announced selections of $350M in projects supporting:
  - Hydrogen storage R&D
  - Fuel cells for consumer electronics and APUs
  - Hydrogen Education
  - Vehicle and Infrastructure Learning Demonstrations

WAYNE STATE RESEARCH & TECHNOLOGY PARK

TECHTOWN

WHERE MINDS AND MEANS INTERSECT.

Recent Awards

Fuel Cells for Consumer Electronics, APUs and Off-Road Transportation

Organization	Amount	Description
Cummins Power Generation	\$3.0 million over 3 years	Solid oxide fuel cell power system for auxiliary power units for Class 7/Class 8 trucks.
Delphi Automotive Systems, LLC	\$3.0 million over 3 years	Solid oxide fuel cell power system for auxiliary power unit for the trucking industry.
IdaTech, LLC	\$1.0 million over 3 years	PEM fuel cell systems for off-road applications.
MTI MicroFuel Cells Inc.	\$3.0 million over 3 years	Direct methanol micro fuel cell technology for consumer electronics.
PolyFuel, Inc.	\$3.0 million over 3 years	Fuel cell power systems for consumer electronics.

Fuel Processing Go/No-Go

History

- Fuel Flexible On-Board Fuel Processing R&D began in 1992

- Focus has been on partial oxidation, catalytic partial oxidation, and autothermal

- Major successes

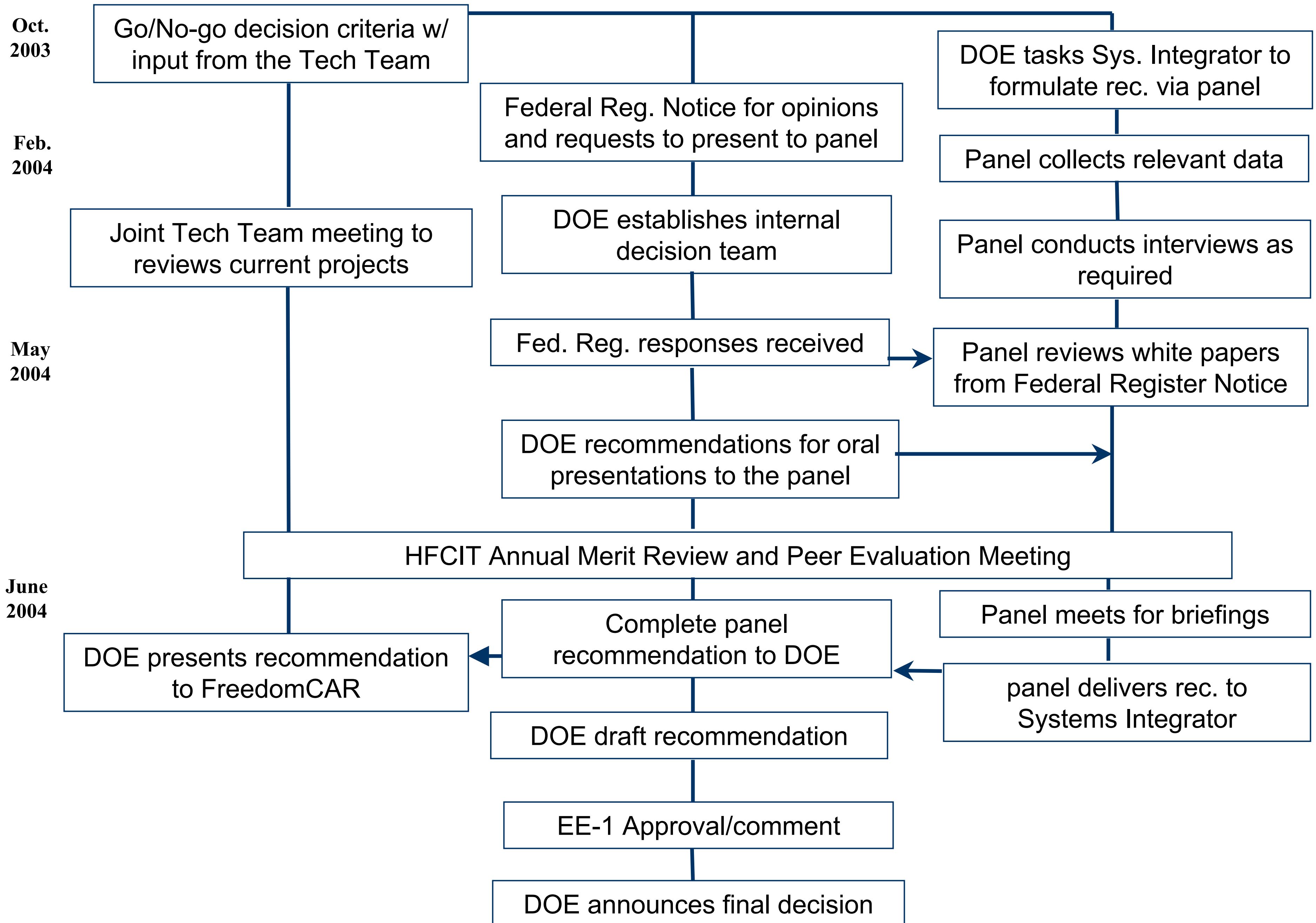
- Major barriers remain (cost, start-up, durability)

- Go/No-Go decision concept developed from sense that development activities were not narrowing the gap to the targets on a time scale appropriate for a bridging technology

Fuel Processing Go/No-Go Criteria

Attribute	Units	2004 Demo Criteria	Ultimate Target
Transient	s	<5, 10% to 90% and 90% to 10%	<1, 10% to 90% and 90% to 10%
Start-up Time (20°C)	s	<60 to 90% traction power	<2 to 10%, <30 to 90%
Start-up Energy	$MJ/50kW_e$	<2	<2
Efficiency	%	78	>80
Power density	W/L	700	2,000
Durability	hours	2000 and >50 stop/starts	5,000 and 20,000 starts
Sulfur Tolerance	ppb	<50 out from 30 ppm in	<10 out from 30 ppm in
Turndown, cost	ratio $\$/kW_e$	20:1 n/a	>50:1 <10

Go/No-Go Decision Flow Chart



Go/No Go Technical Experts Panel

- **Vernon Roan:** Retired professor, University of Florida. Former member of the NAS PNGV review committee.
- **Bill Ernst:** Senior Scientist at Plug Power.
- **Richard Bellows:** Former Exxon and UTC Senior Scientist.
- **Jim Richardson:** Professor of Chemical Engineering at the University of Houston.
- **Jim Fletcher:** Mechanical Engineering Professor at the U. of North Florida. Formerly w/ Georgetown Bus project, UTC and Excellsis.

Future Directions

- DOE considering NRC report recommendation to discontinue stationary systems development.
- Want to explore ways to leverage our continued focus on applied research of components with expanded Office of Science fundamental work supporting fuel cells.
- Implement Go/No-Go decision.